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Reading cities: Developing an urban diagnostics approach for identifying integrated urban problems with application to the city of Birmingham, UK

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ABSTRACT

For policymakers, planners, urban design practitioners and city service decision-makers who endeavour to create policies and take decisions to improve the function of cities, developing an understanding of cities, and the particular city in question, is important. However, in the ever-increasing field of urban measurement and analysis, the challenges cities face are frequently presumed: crime and fear of crime, social inequality, environmental degradation, economic deterioration and disjointed governance. Although it may be that many cities share similar problems, it is unwise to assume that cities share the same challenges, to the same degree or in the same combination. And yet, diagnosing the challenges a city faces is often overlooked in preference for improving the understanding of known challenges. To address this oversight, this study evidences the need to diagnose urban challenges, introduces a novel mixed-methods approach for doing so, applies (and critiques) the approach to the city of Birmingham, UK, and proposes a set of principles for the transferability of this new urban diagnostic methodology to other cities. The paper argues that applying a rigorous, explorative, diagnostic approach to ‘reading cities’ provides confidence that all critical challenges have been identified and, crucially, identifies how they are interdependent, both of which have implications for how policymakers and decision-makers address a particular city’s combination of interlinked challenges.

1. Introduction

If urbanisation is “the defining aspect of our time” (Zhang, 2016, p. 214) then the study of cities must surely be one of the defining aspects of academic study. Over time, the study of cities has entered the purview of many academic disciplines. Shaping cities has, however, largely been achieved through planning – acknowledging the contested nature of planning as an academic discipline (Davoudi, 2015), at least for the last century or so (Healey, 2007). Planning itself has evolved. Victorian planners considered cities as consisting of binary relationships between fixity (land uses) and mobility (infrastructure channels) with urban areas being the conceptual centre of their hinterlands (Healey, 2007). By 1990, networks had become an important conceptual device and cities began to be considered in terms of places and flows (Healey, 2007) as social scientists tried to ‘see’ the city as a mix of networks, actors, human effort and organisation (Amin & Thrift, 2017). Today, planners define cities as complex ‘systems of systems’ consisting of ‘webs’, each with “different space-time patterns of nodes and links” (Healey, 2007, p. 8).

The underlying question for the development of all cities is: planning for what purpose? The answer inevitably is determined by politics and actual or perceived private or public sector failure. Today it might be functionality, economic activity, sustainability, resilience,

liveability, smartness, adaptability, flexibility or meeting citizen aspirations. In truth, planning should embrace all these alongside a deep understanding of the context of the city in question (Rogers, 2018). An underlying challenge is determining how the critical problems being experienced by a city are identified (diagnosed). How different cities go about this varies, as does the degree to which strategic problem identification processes are implemented. For example, problem identification may be politically or socially motivated, may focus on well-known or fashionable challenges, or may follow funding availability. What appears to be absent is the application of a purely explorative and rigorous diagnostic process – one that is an open rather than a closed process; which does not focus upon a specific problem, issue, or system (Malekpour, Brown, de Haan, & Wong, 2017).

A key challenge is how to ‘read’ cities. Mark Twain, in his autobiography, noted how river pilots ‘read’ the Mississippi river (Bryson, Daniels, & Warf, 2004:43). According to Twain, river pilots instinctively navigate the river like a book that they read automatically, without knowing how. Policymakers, planners, urban design practitioners, and city service decision-makers may seek to ‘see’ the city as Amin and Thrift describe it, but they must also learn to ‘read’ it. This process of ‘reading’ is often taken for granted and is akin to searching for known problems.

Existing methods for identifying urban problems fall short of an

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explorative diagnostic approach. This paper develops a new, original, and novel urban diagnostic process intended to 'read' cities. This process is informed by medical diagnostics where abductive and deductive approaches are combined to develop an assessment of a complex system of systems. The study builds upon an extensive body of scholarship examining the challenges faced by cities (described in the literature review) and reveals that explorative urban diagnostics have, surprisingly, been largely overlooked.

This study evidences the need for and describes the design, application and interpretation of an urban challenges diagnostic methodology – a mixed-methods approach to holistically and exploratively identifying a city's challenges through examination of city service-related evidence. This approach is developed from a detailed analysis of the city of Birmingham, UK, but the diagnostics approach can be applied to all cities. The paper focuses on addressing four research questions: (1) What are the current approaches to identifying the challenges facing individual cities and, given these, is there a need to diagnose the challenges of individual cities? (2) Is it possible, in practice, to holistically and exploratively diagnose an individual city's challenges? (3) What methodological problems and gaps arise, and can these be overcome? (4) How can the outcomes be interpreted to aid policymaking and decision-making for addressing urban challenges?

The study synthesises information from several strands of analysis, described in the subsequent sections of this paper, including a review of the urban challenges/problem identification literature; and, a critical assessment of the design, application and interpretation of a new and novel urban challenges diagnostic methodology (taken with UK local authorities, policymakers, urban design decision-makers, urban professionals and academics). The final section explores the study's outcomes and conclusions, including proposing best-practice principles for the transferability of the urban challenges diagnostics methodology to other cities.

2. A review of the urban challenges diagnostic literature

Three literature reviews were undertaken to identify current approaches from across the globe to identifying urban challenges. First, the existence of urban challenges diagnostic studies was explored. Second, a more general review of studies exploring urban problems was undertaken. Third, a review of diagnostic methods outwith the urban studies literature was undertaken.

First, The Web of Science and Scopus were interrogated for studies that identified themselves as conducting an 'urban diagnostics' analysis. The Web of Science identified 24 studies using topic 'diagnostics' and sub-topic 'urban' within the theme 'urban studies'. Scopus identified 4829 studies using topic 'diagnostics' and sub-topic 'urban' within the themes 'environmental science', 'social sciences', 'decision sciences' and 'engineering'. Of the studies returned, most were deductive, narrow and discipline-specific, focussing on one or a subset of pre-determined urban problems (e.g., deprivation, climate adaptation, transport, governance, ecosystem services; see AfDB, OECD, UN, & World Bank, 2013; MacLaran, 1981; Massey, 1996; McKay, Vogt, & Olabisi, 2017; Oberlack, 2017; Rae, 2012; Ruiz & Seguí-Pons, 2018). Current approaches focus on the identification of spatially concentrated deprivation (Rae, 2012; Robson, Lymperopoulou, & Rae, 2008) rather than adopting a focus that highlights the heterogeneity and complexity of intra-urban diversity. Only one study was found to provide a holistic and explorative diagnosis of urban problems: Luque-Martínez and Muñoz-Leiva's (2005) analysis of city benchmarking as a methodological tool through an analysis of Granada. This paper used a breadth of indicators to measure urban performance and then compared this performance to other cities. The variances in performance collectively diagnose a "city's strong and weak points" (Luque-Martínez & Muñoz-Leiva, 2005, p. 415). However, it is worth noting with this method that the choice of comparator city influences the challenges identified and that this study did not develop an intra-urban analysis of place-based

differentials.

Next was conducted a review that took semantics into account, acknowledging that studies that conducted urban challenges diagnostics may not have identified themselves using the term 'diagnostics'. The Web of Science identified 9843 studies using topic 'urban' and sub-topic 'problems' within the themes 'environmental sciences', 'engineering (civil)', 'urban studies', 'planning and development', 'economics' and 'area studies'. Scopus identified 82,605 studies using topic 'urban' and sub-topic 'problems' within the themes 'social sciences', 'environmental science' and 'engineering, econometrics, economics and finance'. Of the returned studies, a typology of four approaches to identifying and understanding urban challenges emerged. Importantly, in all four approaches the existence of the urban challenges is taken as given.

1. Studies that describe, investigate and measure urban challenges (see Alivon & Guillain, 2017; Chen et al., 2017; Garau & Pavan, 2018; García-Ayllón, 2018; Kitchin, Lauriault, & McArdle, 2015; Leach, Lee, Hunt, & Rogers, 2017; Lee & Sissons, 2016; Nichols & Tosun, 2017).
2. Studies that focus upon how best to identify and/or address a challenge or set of challenges, either methodologically or via specific interventions (see Bentham, 1985; Doussard, 2015; Jeong, Lee, & Ban, 2015; Wout, 2013).
3. Studies that assess the efficacy of programmes, policies and technologies designed to address urban challenges (see Desouza & Bhagwatwar, 2012; Glass, 2011; Stren, 1991; Vergara-Erices, Gola Muñoz, & Huiliñir Curío, 2015).
4. Studies that focus upon urban characterisations and ethnographies (see Huxley, 2013; Jacobs, 1961; Knox, 1991; Vernon, 1966)

Finally, a critical review of diagnostic methods was undertaken. Since it was apparent from the previous two literature searches that urban challenges diagnostic methods are rare in the urban studies-related academic literature, diagnostic methods from other disciplines were sought.

Although several disciplines promote methods akin to diagnostics (e.g., design, engineering, foresighting; see Ertas & Jones, 1996; Hunt & Rogers, 2016; INCOSE, 2015; Simon, 1996; Ulrich & Eppinger, 2000), upon investigation these were found not to be synonymous. The medical literature proved to be, perhaps obviously, a natural home for diagnostic methods that were complementary to urban studies. Baerheim (2001) proposes two phases to the medical diagnostic process that have clear synergies with urban studies. Phase 1 comprises the abductive and explorative phase where evidence of a patient's symptoms (a city's challenges) are gathered together and a diagnosis is (or diagnoses are) inferred. Phase 2 comprises the deductive phase, where the diagnosis is (or diagnoses are) tested. The results of the diagnostic tests must then be holistically interpreted (Haasenritter et al., 2013). This approach to medical diagnostics provides a useful conceptual framework for exploring the application of a diagnostic approach to understanding cities.

It is somewhat surprising that there is such limited literature on the application of diagnostic approaches to urban areas and that no rigorous, holistic, explorative, urban diagnostic process has been identified. This might be due to the complexity of urban systems, processes and encounters; it might be due to exogenous factors such as economic and political cycles (e.g., the cyclical nature of the political process makes a diagnostic process problematic, as each election results in a different political interpretation of the challenges); or it could be explained by difficulties related to data availability and methodologies (the former of which varies widely from city to city across the globe). This gap in the literature does not devalue existing approaches to understanding and addressing urban challenges – all are needed to build a rich picture of complex issues. However, determining the malaise of urban areas should not be overlooked and it is this added value that is offered by a holistic and explorative diagnostic approach.

3. A critical assessment of the process of designing, applying and interpreting an urban challenges diagnostic methodology

Having established that no rigorous, holistic, explorative, urban diagnostic process already exists, this section explores the conception, design, application and interpretation of such a process (a detailed description is available in Appendix A). The city of Birmingham, UK, was selected for testing the process as it benefits from extensive study and data availability (building upon the work of [Leach et al. \(2017\)](#)), evidences a particularly acute mix of known problems – most notably governance and the economy ([Kerslake, 2014](#)) and child social care services ([Le Grand, Wood, & Trowler, 2014](#)) – is one of the UK's Core Cities ([Core Cities, n.d.](#)), and it is being governed by a City Council that faces capacity and capability deficits ([Kerslake, 2014](#)) and is actively seeking innovative ways to overcome them.

3.1. Design and application of the urban diagnostic process

A mixed-methods framework ([Brannen, n.d.](#)) for evidence gathering that generated an understanding of Birmingham's city-service challenges was designed, acknowledging the need to incorporate numeric datasets as well as narrative-based documents from across a number of secondary sources ([Luque-Martínez & Muñoz-Leiva, 2005](#)). The framework was informed by the literature reviews and inspired by the medical diagnostic process, focussing upon 'reading the city' through a quantitative and qualitative abductive diagnostic process, the outcomes from which can then be tested through a deductive process (the subject of future research). It sets out how a diversity of evidence types (datasets and documents) are either transferred directly into outputs or are manipulated (analysed) with the resultant outcomes fed into the outputs ([Fig. 1](#)). The outputs are then used to infer a diagnosis of a city's challenges that can be tested through a deductive diagnostic phase.

There were three constraints on the development of this diagnostic process. The first constraint was time-related. The purpose of the case study was to identify the challenges that Birmingham currently faces. As such, data and documents that predated 2010 were not considered unless they remained the most relevant for the city's current situation. This facilitated the capture of longitudinal datasets and documents, many of which recur in 5–7 year cycles. It also included the last UK census, conducted in 2011. This is not to ignore the importance of the past in determining the present ([Martin & Sunley, 2006](#)), and historical investigation will inevitably form part of future deductive diagnoses. The second constraint was relevance to urban services and systems. Urban services and systems were defined to include 'soft infrastructure services and systems' such as education, health, governance and ecosystem services, as well as 'hard infrastructure services and systems' such as energy, water, waste, and transport. These were selected because they offered a breadth of understanding whilst at the same time

providing a boundary to the enquiry. The third constraint was geographical. The primary geographical focus was the political boundary of the city of Birmingham, including some part thereof; i.e., data and documents did not have to reflect the entire city. Using an existing boundary allowed for multiple datasets and documents with different characteristics to come together via a common geography.

A concerted effort was made to include a breadth of types of evidence so as not to limit the diagnostics. Two main evidence types were included: geocoded datasets and documents. For the purpose of this study, datasets were defined as quantitative, numerical and organised into sets that allowed for statistical analysis. Documents could contain quantitative or qualitative evidence, could be in any form (e.g., numerical, categorical, ordinal, narrative) but were not organised into sets in such a way as to allow for statistical analysis. Importantly, this enabled evidence from papers and reports to be included even if the underpinning data were not available. Of note is the importance of including objective and subjective evidence (i.e., citizen perceptions and opinions). A framework for identifying the datasets and documents was established, based on 29 categories of city services (e.g., economy and finance, skills and training, income and poverty) devised collaboratively with Birmingham City Council and at two workshops with policymakers, urban design decision-makers, urban professionals and academics (12 September and 29 November 2016). Each workshop was followed by targeted searches and cross-checking with various information sources (see Appendix A, Table A.1 for the full framework). The evidence base was assessed periodically for thematic and geographical gaps and gluts. The dataset search focussed upon six primary routes of investigation: national datasets, local datasets and surveys, privately held datasets, discussion with Birmingham City Council, identification of thematic datasets at the two workshops, and data from existing policy and project activities across the city. The documents search focussed upon four primary routes of investigation: documents and studies used to create and inform The Birmingham Development Plan ([Birmingham City Council, 2013](#)), other documents held by Birmingham City Council, identification of thematic documents at two workshops, and academic studies.

Despite efforts to identify and capture as many datasets and documents as possible, it was not possible to access all existing sources – and accessing city-scale data is not a new or uncommon problem ([Kitchen et al., 2015](#); [Knox, 1978](#); [Leach et al., 2017](#)). In some cases, this was because the datasets or documents were proprietary, in other cases appropriate permissions could not be obtained in time, occasionally dataset and document owners could not be located and it cannot be ruled out that some datasets and documents simply may not have been identified as relevant. The datasets and documents that were captured were from various sources with varying geographical boundaries, timestamps and cohorts, gathered using different data collection techniques. This inevitably resulted in analysis and interpretational challenges that had to be overcome if the resultant diagnostics were to have meaning.

The variations in evidence types meant that it was not possible to apply a single analysis method to all the datasets and documents. To compensate for this, and to allow for a breadth of possible interpretational outcomes, a mixed-methods approach was taken. Analysis methods were selected for their appropriateness for conducting a diagnostic assessment, suitability to the gathered evidence, and ability to be interpreted together. In order to avoid predetermining outcomes, explorative approaches were selected (i.e., not hypothesis-directed). Two analysis methods were selected, are summarised below and are fully detailed in Appendix A.

1. A principal components analysis (PCA) of 58 variables arising from the 258 identified datasets was conducted using SPSS for the purpose of identifying the most important variables for characterising the city, and their interactions and geographical attributes.
2. An evidence map of 380 identified documents was conducted for the

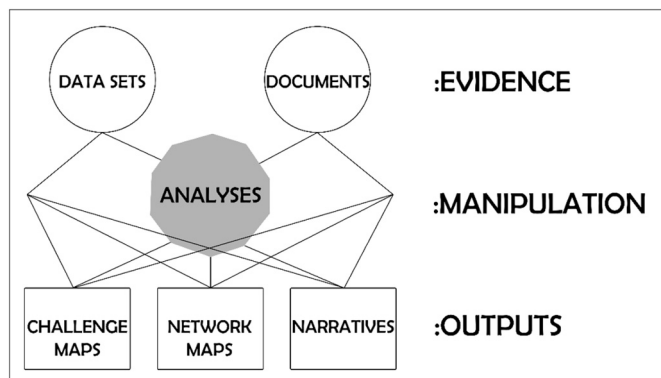


Fig. 1. Conceptual framework for a mixed-methods approach to urban diagnostics.

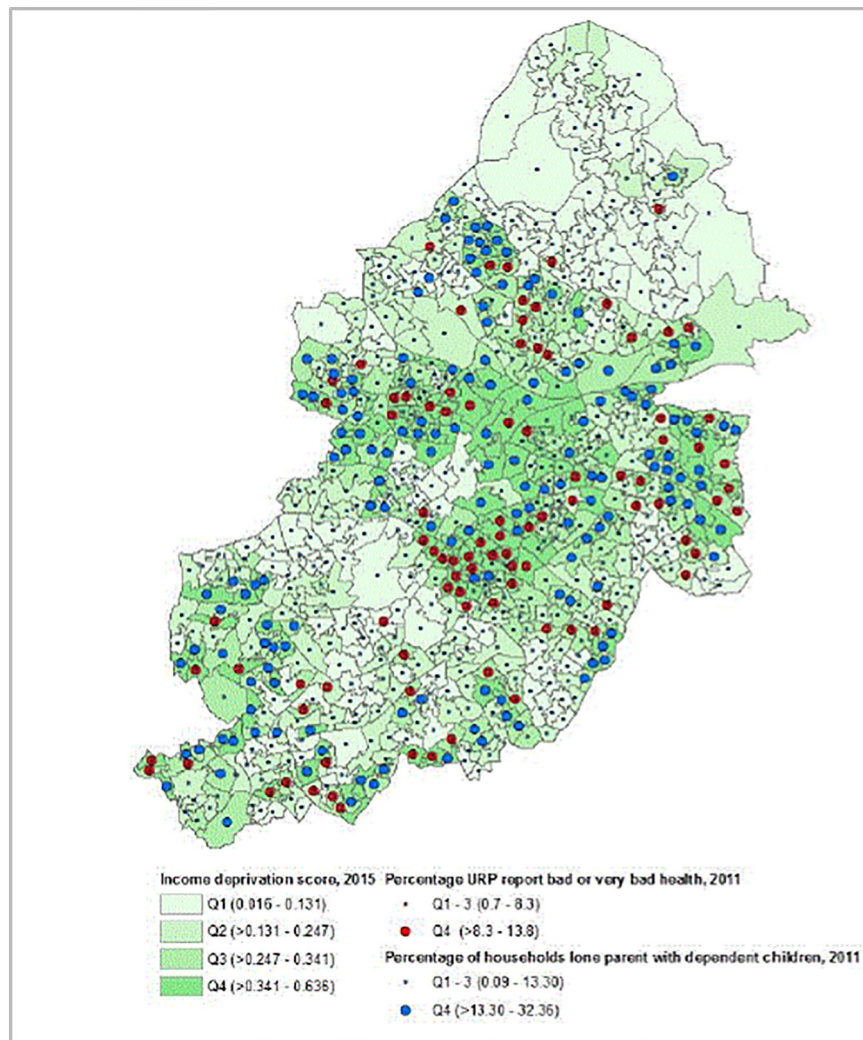


Fig. 2. Challenge map example showing income deprivation, health and lone parent households. Source: Contains National Statistics data Crown copyright and database right 2016.

purpose of determining what is already known about Birmingham, provide pointers to datasets about the city, and to identify common areas of interest and information gaps (McKinnon, Cheng, Garside, Masuda, & Miller, 2015). The evidence map included:

- a network analysis of documents using NodeXL (to understand how the city's services/functions were interconnected),
- a hot & cold spot analysis using NodeXL (to understand how numerous the document themes were), and
- a geographical bias analysis using Excel (to understand the geographical scales covered by these evidence sources).

Three types of outputs were produced, arising directly from the chosen analysis methods: challenge maps, network maps, and narratives. The challenge maps are geographical representations of the principal components analysis (PCA) that illustrate the datasets on maps of the city (for an example, see Fig. 2). Network maps arose from the network analysis and graphically show how the city services/functions (nodes) are connected to each other (links/lines) (for an example, see Fig. 3). Narrative outputs arose from all the analyses. The variations in dataset and document types and analysis methods meant it was not possible to merge these three output types. Instead, the challenge maps, network maps and narratives were interpreted together to identify and explore Birmingham's critical challenges.

3.2. Interpretation of the urban diagnostic process

The outcomes from the Birmingham diagnostics were interpreted in collaboration with local authorities, policymakers, urban design decision-makers, urban professionals and academics as part of an iterative process that involved a workshop to scope the city's challenges, followed by an email engagement to unpick the emerging challenges in some detail and then a final workshop to refine and validate the identified challenges and the diagnostics approach. This process sought to address how the outcomes can be interpreted to aid policymaking and decision-making.

In the first instance, the two analysis methods were interpreted in isolation from each other. The Principal Components Analysis identified five areas of potential critical challenges (challenge areas) for Birmingham, summarised in Table 1.

The evidence mapping identified four challenge areas for Birmingham, summarised in Table 2.

In the second instance, the two analytical methods were interpreted in concert. This included scrutinising them for interconnections and interactions and reducing and refining the identified potential city challenges. Although the challenge areas were identified separately, via different analysis methods, it was obvious that there were considerable thematic overlaps, interconnections, dependencies (i.e., one-way dependency) and interdependencies (i.e., two-way dependency). A

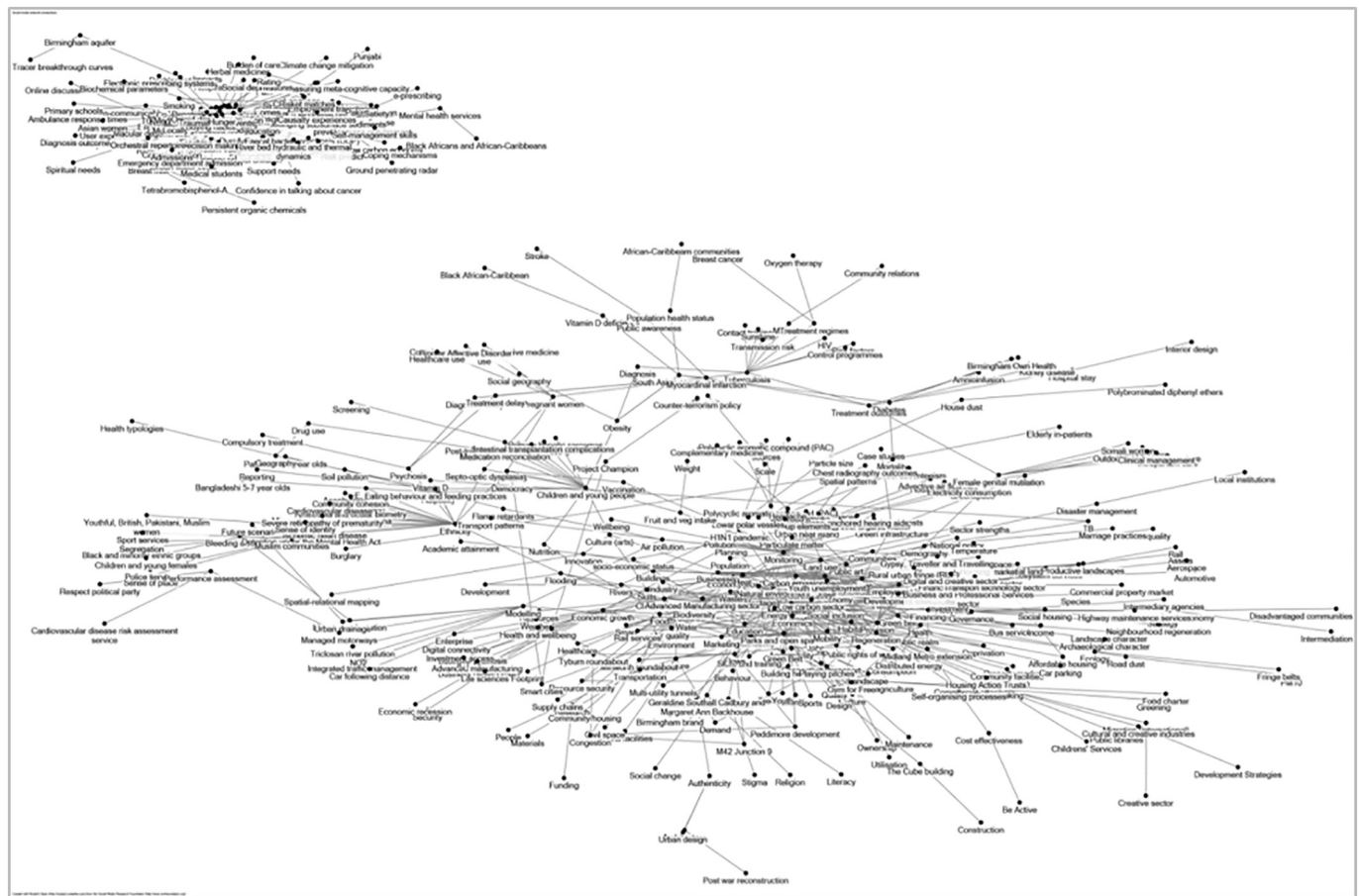


Fig. 3. Network map example showing a Harel-Koren Fast Multiscale network visualisation of city service foci.

comparative analysis revealed that both the PCA and the evidence map had identified four common challenge areas (in all or part) that are specific to Birmingham:

1. Connectivity
2. Economy
3. Energy
4. Health & wellbeing

It then became evident that the PCA statistically linked ‘health &

wellbeing’ to ‘connectivity’, ‘health & wellbeing’ to ‘economy’ and ‘health & wellbeing’ to ‘energy’, underscoring the importance of health & wellbeing as a critical challenge area for Birmingham. In addition, the evidence mapping strongly indicated that ‘governance’ is also a critical challenge area for the city and could be established as an overarching challenge. Collectively, these became the ‘Birmingham critical challenges plexus’ (Fig. 4).

At the outset of this study it had been expected that the outcomes from the mixed-methods diagnostics would mirror the challenges that were already apparent within the city of Birmingham and might

Table 1
Results of the Principal Component Analysis (PCA) of Birmingham datasets.

Challenge area	Interpretation
1 There is a significant socio-spatial divide across the city with regard to economic advantage, equity and healthy households	There is a clear spatial divide in the level of economic advantage across Birmingham. The north of the city and parts of the south record higher proportions of resident populations with these characteristics. Counter to this, income deprivation is clustered in the central band across the city. This area also has higher levels of lone parents with dependent children, long term unemployment and the lowest value housing stock.
2 There is a significant socio-spatial divide across the city with regard to healthy living environments and community prosperity	The outer city core has a distinct community group, with higher levels of black and ethnic minority residents and also non-UK born residents. This distinct spatial band around the city core reflects a transition zone that has disadvantaged living conditions, lower quality outdoor environments and lower levels of economic activity.
3 There is a non-spatial relationship between the level of connectivity, associated access to services and levels of life satisfaction	There is a relationship between the level of connectivity, associated access to services and levels of life satisfaction. This suggests a challenge around relative ‘distance’ and transport networks within the city to support community-based approaches to wellbeing. The interaction extends across the city and shows no clear spatial pattern or hotspot of disadvantage for accessibility.
4 The city core has a distinct sub-profile	The zone around the immediate city core is disconnected from the regeneration of various parts of the centre. Increased levels of negative liveability suggest the area is not integrated with the prosperity and brand of the city centre.
5 There is a disconnect between the natural and urban form of the city and the resident population characteristics	Of particular interest is that density is not related to socio-demographics, resource use or connectivity within the city.

Table 2
Results of the evidence mapping of Birmingham-related documents.

Challenge area	Interpretation
1 Promoting healthy living and healthy long lives	The network analysis showed a clear disconnect between an extensive, highly specific and narrow academic medical literature and policy literature, which deals with health and wellbeing in little detail. The hot & cold spot analysis showed 'health and wellbeing' in the top two literature hotspots (linking most often with itself and then with demography). At the ward scale health outcomes are variable and clearly health and healthcare do not follow ward boundaries (or ward-level policies). Health and healthcare cut across city services, drawing in the medical health system, green spaces, transport and food, for example. This challenge also touches upon gaps in knowledge, such as Birmingham's food demand profile.
2 Minimizing high-carbon mobilities whilst maximizing connectivity	The hot & cold spot analysis showed 'mobility and transport' as the third and fourth top literature hotspots (linking most often with itself and then with creating an evidence base). Some wards suffer from disproportionately high levels of traffic congestion whilst other wards (notably those further away from the city centre) have poorer access to public transport. Some wards are less connected in non-physical ways. For example, some wards rely more heavily upon working practices that don't lend themselves to working remotely and some wards have higher percentages of older residents who are less likely to use digital services.
3 Reducing environmental risks through the sustainable use of low-carbon energy	The hot & cold spot analysis identified environmental risks associated with carbon emissions, air pollution and flooding as the last of the top five hot spots. Surprisingly energy, the largest contributor to climate change and the resultant environmental risks, was identified as a cold spot. Energy does form part of city-scale and ward-scale policy documents, primarily in relation to reducing carbon emissions, featuring in general terms and it is clear that in recent years (and in particular following the Financial Crisis) reducing carbon emissions and being environmentally friendly has fallen down Birmingham City Council's list of priorities (and economic growth has come up this list, setting the scene for obvious tensions between growing whilst reducing high-carbon energy demands).
4 Developing appropriate governance models to ensure economic vitality and establish the city's brand	The link between economic performance and city governance is less evident from the evidence mapping, but is generally evident in the academic literature and was highlighted repeatedly in the workshops and email engagement. Economic performance (especially in relation to growth) and city governance are, without doubt, two of Birmingham City Council's top priorities. The Kerslake Review captured the city's governance challenges, with an emphasis upon the need for effective leadership and visionary thinking and reflecting an apparent lack of confidence in Birmingham's policymakers to be able to create an economically vibrant city, something that was mirrored at the workshops and in the email engagement. This lack of confidence is, perhaps, reinforced by the city's science-policy gap (revealed by the network analysis), its narrow and disconnected understanding of itself (revealed by the hot & cold spot analysis) and its geographically piecemeal evidence base (revealed by the geographical bias analysis). It also has knock-on effects upon attracting inward investment, new businesses and new residents and establishing the Birmingham brand.

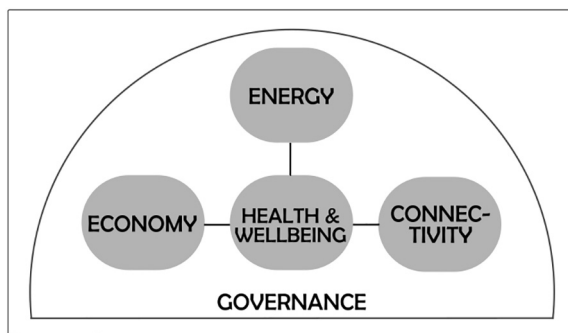


Fig. 4. Birmingham's plexus of critical challenges.

potentially identify additional challenges. Although no new individual challenges were revealed, the mixed-methods approach had the consequence of enabling concurrent interpretation across various analysis methods and this made it possible to identify those challenges that could be considered critical within the city and – importantly – to link them together. This resulted in the identification of an urban plexus of four challenges (all connected by health & wellbeing) and an overarching challenge (governance) giving rise to the implication that interventions (planning, policy or otherwise) should seek to address the plexus as a whole. This is in line with the current conceptualisation of cities as complex systems of systems (Healey, 2007). The implication is that a health and well-being intervention has to be simultaneously an economic, connectivity and energy policy. Siloed policy interventions will produce perverse consequences or result in policy failure.

When the plexus was cross referenced with the City Council's published priority areas (children, housing, jobs & skills, and health (Birmingham City Council, n.d.)) there was clearly some mismatch.

This raises the question as to what might the implications be for a city if the local authority promotes policy priorities that do not address the city's critical challenges and plexus.

It is possible to envisage identifying critical challenge plexuses in cities other than Birmingham. A comparison across plexuses may reveal common plexus elements, perhaps even common complete plexuses that could (should) be addressed at national or even global scales. Understanding the relationships between the critical challenges of multiple cities in this way offers the promise of illuminating critical points of intervention and thus focusing to deliver the greatest effect from scarce resources. It speaks to thinking beyond 'city systems' to 'systems of cities' and it moves the 'urban challenges diagnostic methodology' described herein towards becoming a 'challenges of urbanisation diagnostic methodology'.

Although the Birmingham critical challenges plexus provided a useful evidence base and framework within which Birmingham's policymakers and decision-makers could think about the challenges faced by the city, it did not provide specific insights into how to address them. For this, further, deductive diagnostics are clearly needed (and are the subject of future work).

4. Discussion and conclusions

Cities are complex interdependent systems of soft and hard systems. Existing approaches to understanding urban challenges have tended to focus on previously (often politically) defined challenges rather than the identification of challenges by a more independent and objective diagnostics process. This study has explored the development of such a process for the first time by drawing upon approaches developed in medicine. A medic develops an overview of a patient by reading signs displayed by a patient. An abductive diagnosis is made and then a process of testing commences (deductive diagnostics). The application

of this process to cities provides an approach in which an assessment of assumptions of the challenges facing a particular city can be tested through a more formal evaluation of data.

Cities are where opportunities and challenges emerge from a complex confluence of multiple individual and societal activities, the built environment, infrastructures, the economy, the natural environment and numerous systems of formal and informal governance. The approach to urban diagnostics developed in this paper was based on the analysis of a large city, but the approach can also be applied at various densities of living and geographical scales. This diagnostic methodology is both globally transferable and scalable: via a common geography it provides a framework for bringing together datasets and documents with different characteristics, and via a layered geography it allows for replication to other areas (smaller and larger). Datasets and documents that have national coverage are supplemented and enhanced by locally-defined and collected evidence that adds richness to the analysis – built within a framework that makes comparisons between places possible.

This study found that there are almost no existing studies where an individual city's challenges are holistically and exploratively diagnosed through an open process that does not focus upon a specific problem, issue, or system. The reasons for this are not fully clear. One possible contributing factor is the long-term, dynamic-yet-incremental nature of some city challenges. Intractable challenges, such as poverty and inequality, are understood and addressed over decades. Such challenges are complicated to address and there is no 'magic bullet' for quick and easy resolution. Such challenges also become part of the fabric of a city – perceived as ever present. Another possible contributing factor is that some challenges can probably be found, to a greater or lesser extent, in all cities. The recent and global emancipation of data (Kitchin et al., 2015) and its use in measuring and monitoring cities in particular (Leach et al., 2017; Symons, 2016) has given rise to an increasing number, and sophistication, of studies exploring city challenges (Leach et al., 2017). However, it seems these data are not being used to diagnose urban challenges, but rather to better understand and address known challenges. This study argues that using data to diagnose a city's critical challenges is as important as using the data to address those challenges (and, potentially, influences how they are addressed, as with Birmingham's challenge plexus). Without diagnostics, electoral cycles and visible problems disproportionately influence planning and policy interventions. An urban diagnostics approach provides planners and policymakers with the opportunity to create a grounded set of evidence-based interventions alongside a set of benchmarks of city performance against which future city performance can be compared.

This study designed a mixed-methods approach to urban challenges diagnostics and successfully applied it to the city of Birmingham, UK. Although the outcomes of the analysis did not identify any previously unknown challenges within the city, they did identify a plexus of critical challenges that the authors argue should be collectively addressed rather than addressed in isolation if interventions are to be effective.

In addition, the following insights emerged regarding the potential to transfer the urban challenges diagnostics methodology to other cities across the world.

- Urban challenges diagnostics should be applied for the purpose of holistically and exploratively identifying the (potentially critical) challenges faced by a city, *and* their interactions. Moreover, with limited time and resources, an urban challenges diagnostics method has to be bounded to make it manageable: the limits should be made explicit and should seek to retain as holistic and explorative an approach as possible. Bounding with regard to time, areas of focus and geography were successfully used in the Birmingham case study. Furthermore, urban diagnostics should seek to include as wide a breadth of evidence types as possible, including datasets and documents (especially as availability issues are likely to limit analyses). To paraphrase: if you analyse what you've always analysed you will get the results you always got. Thinking creatively about

what constitutes usable evidence may lead to identifying new sources. A comprehensive data and evidence identification framework was developed for this study.

- Analysis techniques should be selected to match the gathered evidence, not the other way around, so as not to unnecessarily limit the breadth of the evidence. For this study a principal components analysis was chosen to analyse the datasets as it is a proven explorative method for preliminary data analysis. Similarly, building an evidence map was chosen to analyse the documents as it is a proven explorative method for identifying information and geographical gluts (i.e., data hotspots) and gaps. Crucially, it is important to recognise that it is highly unlikely that all the evidence will be able to be analysed using a single technique. Complementary analysis techniques should be selected so as much of the available evidence as possible is analysed in some way, even if those ways are different. For this study, the PCA and evidence map methods were selected as they provided explorative oversights of the evidence with only minimal segmentation of the evidence.
- Robust and repeatable (and, if possible, innovative) analysis techniques should be selected that interrogate the evidence from a variety of angles and in complementary ways. In this study, the methodological refinement and application of evidence mapping for the purpose of identifying urban challenges is both innovative and new. The research revealed two further critical lessons: Firstly, care should be taken not to bias outcomes by using hypothesis-driven approaches. Secondly, interpreting outcomes from different analysis techniques using varying evidence sources (likely with different geographical, cohort and time elements) is challenging and requires those interpreting the outcomes to have experience in research synthesis and interpretation, as well as a good knowledge of the city under study. To assist with this, consulting as broadly as possible is desirable. For the Birmingham case study policymakers, urban design decision-makers, urban professionals, and academics, all of whom were familiar with Birmingham, were consulted.
- Interpretation of the diagnostic outcomes should take cognisance not only of the challenges that have been revealed, but also where the gaps in knowledge are located (i.e., what are the analyses *not* saying, how might missing evidence bias the outcomes?). In the same vein, biases should be made explicit. For example, do the evidence and data hotspots arise because they reflect research funding hotspots, ease of data availability or local authority priorities; do the study's bounding criteria provide a skewed perspective?
- Cities don't behave in isolation within their own borders, and in terms of the challenges they face change over time. Interpretation should consider how representative the diagnostics are of these elements.

Perhaps the most important question those conducting an urban challenges diagnostics analysis can ask is: are the diagnostic outcomes a true reflection of the city's challenges? Answering this question requires critical reflection upon the diagnostic methodology and its outcomes alongside consultation with local authorities, planners, policymakers, urban design decision-makers, urban professionals, academics, businesses, financiers and communities. The diagnostic approach taken in this study was inspired by the medical literature, and yet medical diagnostics are not as scientific as they might appear. Medical diagnostics are both an art and a science. Some symptoms are read without, perhaps, any explicit appreciation that they have been seen or considered – in other words, diagnostics can be, in part, intuitive (Brush, Sherbino, & Norman, 2017). Medical diagnostics are also partly subjective, with some symptoms being more subjective than others (Pallagrosi, Fonzi, Picardi, & Biondi, 2016). There is no reason to think urban diagnostics are any different.

It might be argued that the problems faced by any given city are well known. Birmingham's local government certainly thought this: that

it knew what the city's challenges were and thought that the main problem it had was in effectively addressing those challenges. This study revealed that this was not necessarily the case and it makes the argument that urban diagnostics can lead to reconceptualising a city's challenges (in Birmingham's case, as an interconnected system of critical challenges: a plexus), which can lead to more effective ways of addressing them.

Effectively and efficiently addressing urban challenges is increasingly important (Acuto, Parnell, & Seto, 2018); however, the degree to which new strategic frames, such as a city's 'critical challenges plexus', overlap with those of other cities, travel in tact (i.e., move from one department, organisation or group to another) and the degree to which they are lost, in whole or part, through translation back into established systems (Healey, 2007) materially affects their potential to create better outcomes for people.

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Data statement

All data created during this research are openly available from the University of Birmingham data archive. The Principal Components Analysis (PCA) dataset is available from <https://edata.bham.ac.uk/241/>, DOI 10.25500/eData.bham.00000241. The evidence analysis dataset is available from <https://edata.bham.ac.uk/240/>, DOI 10.25500/eData.bham.00000240. Application of the PCA and evidence analysis are published in full in the supplementary data for this paper.

Declaration of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.cities.2018.09.012>.

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